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(54) **MULTI-PHASE CONVERTER WITH
BALANCED CURRENTS**

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(58) Field of Search **323/271, 272, 323/282, 284, 224, 225, 285**

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,137,274 * 10/2000 Rajagopalan 323/272

OTHER PUBLICATIONS

Semitech, "Programmable, High Performance Multi-Phase, PWM Controller SC 1144", Semitech, 1999, p 1-11, Jul. 7, 1999.

Harris Semiconductor Corporation, "Microprocessor Core Voltage Regulator Multi-Phase Buck PWM Controller HIP6301", Harris Semiconductor Corporation, 1999, p 1-8, Jul. 1999.

Harris Semiconductro Corporation, "Multi-Phase Buck Technology", Harris Semiconductor Corporation, 1999, p. 1-12, Apr. 4, 1999.

* cited by examiner

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(57) **ABSTRACT**

A multi-phase DC/DC converter having an output voltage and including a plurality of converter channels. Each converter channel includes a converter channel input and a converter channel output. Each converter channel is configured for generating a converter channel current and for adjusting said converter channel current in response to a control signal electrically connected to each converter channel input. A control circuit generates an error signal representative of a comparison of the converter output voltage to a reference voltage. The control circuit includes a plurality of control circuit channels, each of which correspond to a converter channel. Each control circuit channel generates a channel current signal representative of a corresponding converter channel current, and generates a differential channel current signal representative of a comparison of the channel current signal to an average current signal. The average current signal is representative of an overall average current for the converter channels. Each control circuit channel generates a differential error signal representative of a comparison of the error signal to the differential channel current signal. Each control circuit channel includes a pulse width modulator having a ramp input and a control input. The control input is electrically connected to the differential error signal. The pulse width modulator generates the control signal based upon the differential error signal. The control signal is electrically coupled to a corresponding converter channel input. The control circuit generates the average current signal.

18 Claims, 2 Drawing Sheets

